CE 418.3 - Design in Reinforced Concrete

FINAL EXAMINATION

December 8, 2001

Time Allowed: 3 Hours | Professor: B. Sparling

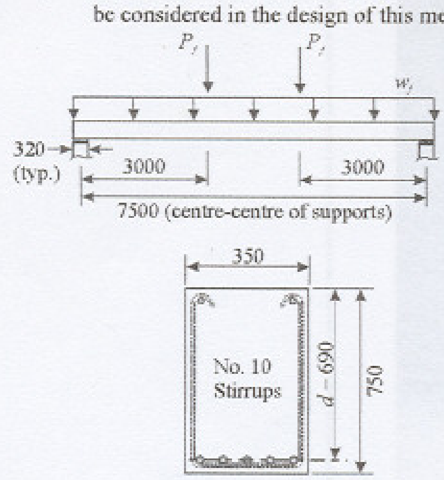
Notes:
- CPCA Concrete Design Handbook may be used
- Closed book examination ; Calculators may be used
- The value of each question is provided along the left margin
- Supplemental material is provided at the end of the exam (i.e. formulas)
- Show **all** your work, including all formulas and calculations
- Hand in your examination sheet along with the answer booklet.

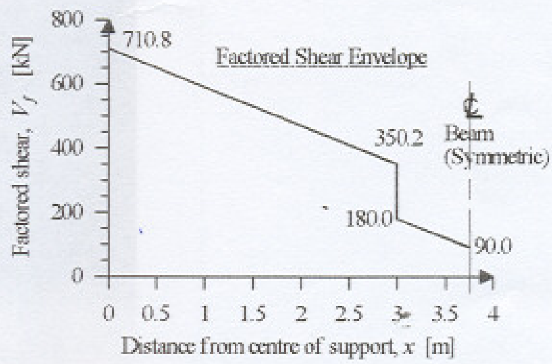
MARKS

QUESTION 1: The simply supported reinforced concrete beam illustrated below is subjected to loading as shown. The resulting factored shear envelope to be used for design (accounting for all critical load patterns) is also provided. This shear envelope starts at the centre of the left support and is symmetric about midspan of the beam. The beam is constructed using concrete with $f'_c = 30$ MPa and Grade 400 reinforcement. Provide answers to the following questions, using the Simplified Method given in Clause 11.3 and satisfying all relevant requirements of CSA A23.3-94.

15 **a)** Determine the required spacing for stirrups of the type shown below at exactly 2.0 m to the right of the centre of the left support. Give the spacing as found from your calculations without any rounding.

5 **b)** Is the beam size (cross-sectional dimensions) adequate for the maximum shear force that must be considered in the design of this member? Justify your answer.

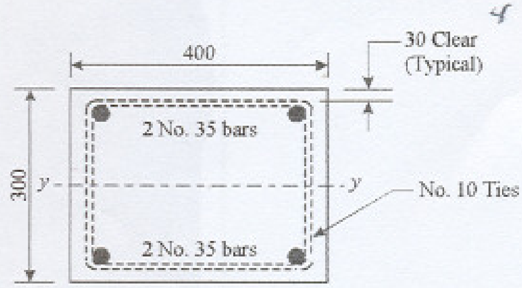




QUESTION 2: The column shown below is constructed using concrete with $f'_c = 35$ MPa and Grade 400 reinforcement. In addition to an axial load P_f, the column is subjected to a bending moment M_f applied about the y-y axis. Use CPCA Design Handbook aids to answer the following.

6 **a)** Determine the moment resistance M_r for the column if the applied axial force is $P_f = 1{,}500$ kN.

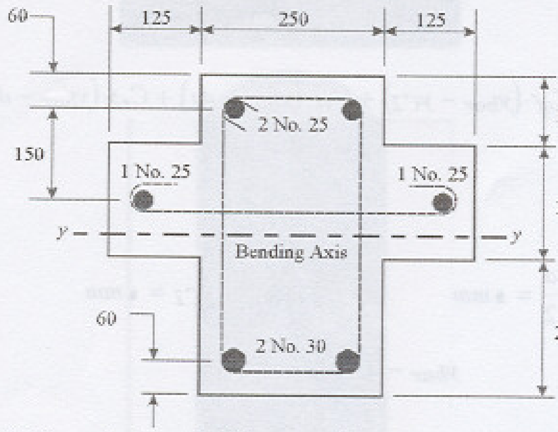
4 **b)** If only the **size** of bars changes, with the number and configuration of bars remaining the same, select the minimum bar **size** that will provide a moment resistance of $M_r = 85$ kN·m for the case when there is no applied axial load ($P_f = 0$ kN).



QUESTION 3: The cruciform (cross) shaped column shown below is constructed using concrete with $f'_c = 30$ MPa ($\alpha_1 = 0.805$ and $\beta_1 = 0.895$) and Grade 400 reinforcement. Assume all bending occurs about the *y-y* bending axis such that the top face experiences the highest level of compressive stress.

10 **a)** Locate the plastic centroid of the section.

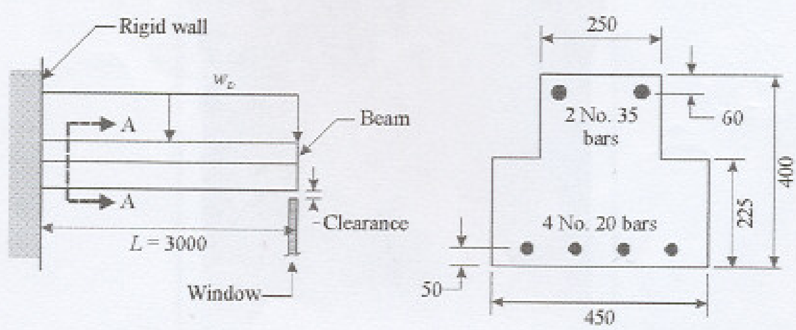
15 **b)** Using the basic principles of force equilibrium and strain compatibility, calculate the factored axial load and moment resistance of the column for the condition when the 2 No. 30 bars on the bottom face experience a stress of $f_s = 0.5\,f_y$ in tension. If you did not complete Part (a), assume the plastic centroid of the section is at mid-depth to answer Part (b).



QUESTION 4 : An inverted T-beam cantilevers 3.0 m out from a rigid wall. The beam supports a uniformly distributed dead load, including its own self weight, of $w_D = 8.0$ kN/m but does not support any live load. The beam is constructed using concrete with a design strength of $f'_c = 30$ MPa and an elastic modulus of $E_c = 27{,}000$ MPa, and Grade 400 reinforcement. The moment of inertia for the gross concrete section is given as $I_g = 1.761\times10^9\ \text{mm}^4$; the centroid of the gross section is located 172.8 mm above the base.

12 **a)** Calculate the "effective" moment of inertia I_e for the beam based on provisions in CSA A23.3-94. **Hint:** The centroidal axis for the cracked section is located within the 450 mm wide bottom flange of the beam. Also, the maximum moment a cantilever beam (at the supporting wall) subjected to a uniform load is given by $M = -\frac{1}{2}\,w\,L^2$.

8 **b)** A window is to be installed under the free end of the cantilevered beam after the structure is built and all of the dead load has been applied. What is the minimum clearance required between the bottom of the beam and the top of the window so that they will never come into contact? The elastic deflection at the free end of a cantilevered beam subjected to a uniformly distributed load is $\Delta = \dfrac{w\,L^4}{8\,E\,I}$. If you were unable to complete Part (a), assume an effective moment of inertia of $I_e = 1.0\times10^9\ \text{mm}^4$ to answer Part (b).



Section A-A